

## OBLIQUE, ASEPTIC, END-TO-END ILEAC ANASTOMOSIS, PROCEDURE OF CHOICE IN STRANGULATING SMALL BOWEL OBSTRUCTION

CLARENCE DENNIS, M.D., Minneapolis, Minnesota

UNLESS there is a compelling contraindication, most surgeons prefer exteriorization to resection and the performance of primary anastomosis in the presence of strangulating obstruction of the small intestine. The chief compelling indication for a primary anastomotic procedure instead of exteriorization has been considered a high situation of the lesion, a situation in which intestinal fistula is definitely hazardous.

During the past 2 years, resection and primary anastomosis have become the procedure of choice at the University of Minnesota Hospitals in the management of small intestinal obstruction complicated by the presence of nonviable bowel, either from strangulation or other cause. This procedure started with an infant of 5½ weeks who recovered after resection of a gangrenous intussusceptum, a procedure performed with a background of experience with end-to-end anastomosis in dogs. In subsequent cases patients have been treated in similar fashion, until now 16 consecutive cases (15 patients) have been treated in this

manner, with 2 deaths. In similar groups of cases in which older methods were used, the mortality rate has been reported at varying levels from 30 to 50 per cent (6, 15).

### TECHNIQUE OF ANASTOMOSIS

The type of procedure used in most of these cases is an oblique, aseptic, end-to-end anastomosis, a modification of that described by me 4 years ago (1), which is in turn a modification of that of Martzloff and Burget (8). One of the chief difficulties which this procedure is designed to overcome is the end-to-end union of segments of widely differing diameter without the formation of blind pockets, kinks etc. In order to clarify presentation, the details of the procedure as now used will be presented at this point.

The mesentery is meticulously cleaned from the distended bowel proximal to the point of obstruction, a site close to the point of approach of large vessels in that mesentery being chosen (Fig. 1). A slender, crushing, anastomosis clamp is placed across the bowel, from the antimesenteric border, at an angle of about 75 degrees from the long axis of the gut. The clamp crosses the mesenteric border about 6 millimeters below the edge of the unremoved mesentery.

From the Department of Surgery, University of Minnesota.  
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In order to minimize the danger of spillage of any of the content of the distended bowel during the later stages of the procedure, the contents are cautiously milked back between the fingers for 10 or 20 centimeters from the clamp, and a rubber-shod intestinal clamp is lightly applied. This clamp remains in place until the completion of the anastomosis.

Below the point of obstruction, the diameter of the bowel is usually one-third to one-half that above, and the anastomosis clamp must therefore be placed much more obliquely to attain a length of crushed tissue equal to that above. Most satisfactory stomas have been achieved by the application of the clamp *from the mesenteric border* with distortion of the bowel by Allis forceps lightly applied in such fashion that the line of crush, beginning at the mesenteric border, crosses obliquely two-thirds of the way to the antimesenteric border, then runs longitudinally down the bowel to gain the necessary length of crush before it crosses the remainder of the gut (Fig. 2, 2a). The cleaning of the mesentery and the placement of the clamp with regard to the cleaned area are accomplished as on the distended intestine.<sup>1</sup>

A similar clamp is placed between the bowel to be resected and each of the clamps already described, a 3 or 4 millimeter gap usually being left between clamps. The intestine is cut in the gap between each of these pairs of clamps with the actual cautery (Fig. 3).<sup>2</sup>

The anastomosis clamps are laid side-by-side, thus bringing the bowel ends together with one end rotated 180 degrees with respect to the other about the long axis of the gut (Fig. 4). Ideally the length of the area of crush in the 2 clamps is identical, for by this precaution the most accurate apposition of the 2 ends can be attained in making the anastomosis. The clamps are rotated away from

each other, and a running basting stitch of No. 000 or No. 0000 plain catgut on an atraumatic needle is placed posteriorly, about 5 millimeters being taken in each bite, with a slightly smaller gap (4 mm.) being left between bites. Subsequent inversion occurs spontaneously at the time of withdrawal of the clamps *only if the ends of the running sutures are properly placed*; inversion of the corners with instruments, which invites contamination, may thus be avoided. Each end bite of each suture must be about 5 or 6 millimeters long and parallel with the axis of the bowel and should emerge close to the clamp (Fig. 4a).

The anastomosis clamps are now rolled together, and a similar running stitch is placed anteriorly (Fig. 5).

Tension is applied to the two ends of each of the basting sutures, the clamps are carefully loosened until the tips are spread 1 or 2 millimeters, and the clamps are cautiously and simultaneously withdrawn (Fig. 6). If the sutures have been properly placed, inversion of the cut ends of intestine will occur with no further manipulation, and clean serosal approximation will result. Tension is maintained on the basting stitches while the ends of the posterior strand are tied to the corresponding ends of the anterior strand.

With maintenance of tension on the ends of the basting stitches throughout, interrupted Halsted mattress sutures of 2½ pound test silk<sup>3</sup> are laid anteriorly, 20 or 30 milligrams of sulfanilamide (or sulfathiazole) is implanted on the serosa between the rows of sutures (Fig. 7), and the mattress sutures are tied *just tightly enough for snug apposition* (Fig. 8). The bowel is rolled over, and the posterior closure is similarly re-enforced, tension being continued to this point on the ends of the catgut strands. Tension on the basting sutures is gradually lessened as the stoma is broken down by inverting the bowel below the anastomosis with a thumb or two fingers and thus pushing through the stoma. The catgut basting stitch, which is circular by virtue of the knots at the ends of the suture line, is held taut by this device while inversion Halsted mattress sutures are placed at the ends. The catgut ends are cut, sulfonamide is lightly

<sup>1</sup> The value of this type of placement is not limited to anastomoses performed in the presence of obstruction. In the terminal ileum under normal conditions the lumen is small enough to render anastomosis without undue reduction of the lumen difficult. This type of placement of clamps with 180 degrees' rotation has proved uniformly successful under these circumstances. In other sites where bowel ends of unequal diameter are to be joined, such as in end-to-end ileocolostomy after right hemicolectomy, this type of anastomosis has also proved uniformly successful.

<sup>2</sup> In the experimental work the gut was transected with a knife, and the 1 millimeter portion extending beyond the clamp was thoroughly phenolized, then treated with alcohol and dried. With the acquisition of the clamps described, which are heavier than those used for most of the experimental work, it was found that the bowel could be cut flush with the anastomosis clamp without pulling through it during the procedure. It did not seem to matter in the healing whether the bowel was cut with cautery or knife.

<sup>3</sup> Cotton of similar strength was used in the experimental work.



Fig. 1.

Fig. 2 and 2a, above.

Fig. 1. Placement of the first anastomosis clamp on the distended bowel above the point of obstruction. The clamp crosses the bowel at an angle of 75 degrees and at the mesenteric border about 6 millimeters from the edge of the unremoved mesentery. The bowel has been milked back and a rubber-shod clamp is applied to prevent spillage.

Fig. 2. Placement of the second anastomosis clamp on the contracted bowel below the point of obstruction. The line of crush begins 6 millimeters from the unremoved mesentery, crosses obliquely  $\frac{2}{3}$  of the bowel and passes for a distance parallel with the antimesenteric border before crossing the remaining  $\frac{1}{3}$  of the bowel, a. This length of crushed tissue, equal to that in Figure 1, is obtained by distorting the bowel with Allis forceps. This clamp is placed from the mesenteric border.

placed, the silk sutures are tied, and the anastomosis thus completed.

To close the mesenteric defect, a stitch near the center of the posterior suture line is threaded on a needle and a small bite of each mesenteric edge is taken 3 centimeters from the bowel (Fig. 9), and behind it, and thus the defect in the mesentery is tied. From this point to the root of the mesentery, interrupted silk sutures are placed. Efforts to cover the suture line with omentum have been abandoned as useless. Sulfonamides have not been generally implanted into the peritoneal cavity because it has seemed that this procedure leads to excessive adhesion formation.

The clamps used in making this anastomosis differ from those of Martzloff and Burget (8) in that they are shorter and lighter (Fig. 10). With the shorter clamp one may

rely less on the springiness of the instrument to crush the tissue at the tip, and the clamps may therefore be more easily removed during the anastomosis. Deep, sharp, longitudinal, matching grooves are cut on the jaws of the clamp.

The advantages of this type of anastomosis over many of those described in the literature have been discussed in a previous paper (1). Certain advantages will be emphasized at this point:

1. End-to-end anastomosis avoids the formation of the blind pouches which result from closure of both ends and side-to-side anastomosis.

2. End-to-end anastomosis necessitates but one suture line, whereas closure of the ends and side-to-side anastomosis requires three lines.



Fig. 3.

Fig. 4.

Fig. 4a.

Fig. 3. Cutting the bowel between the clamps described in Figure 1 and Figure 2 with the cautery. To prevent spillage additional clamps are placed between those applied for anastomosis and the specimen to be removed.

Fig. 4. Placement of the posterior running fine catgut suture. The clamps are held side-by-side, so that the bowel ends are brought together with 180 degrees' rotation of one with respect to the other. The suture is laid with the clamps rolled away from each other as shown. The bites are 5 millimeters long and the gaps between bites are 4 millimeters. a, Placement of each end bite parallel with the long axis of the gut assures good inversion later.

3. Aseptic procedure permits apposition of serosal surfaces uncontaminated with luminal contents.<sup>1</sup>

4. Obliquity of placement of clamps permits the best possible blood supply to the line of suture, for the vessels follow a circular course around the bowel and are not, therefore, interfered with before reaching the suture line.

5. Rotation of one segment of bowel with respect to the other minimizes angulation and therefore minimizes possibility of obstruction at the point of anastomosis, as shown in Figure 11.

6. Rotation of the bowel avoids the dangers of closure without peritoneum at the

mesenteric border; in other words, by this rotation peritoneum is provided on one surface or the other completely around the line of inversion.<sup>2</sup>

7. This type of anastomosis avoids the danger of stenosis at any time in the post-operative period. There has been no case of dysfunction secondary to the quarter twist imposed on each end to be anastomosed.

#### CLINICAL CASES

On 16 occasions between November 1, 1940, and March 1, 1943, nonviable segments of small intestine have been resected in the presence of small intestinal obstruction. These are consecutive cases, no patient with gangrenous bowel and obstruction having been

<sup>1</sup>The experimental data presented illustrate this point only fairly well because of the small number of open anastomoses; but comparison of the results here reported with those of Owings and Smith, who used open procedures exclusively, furnishes abundant evidence in favor of the present procedure.

<sup>2</sup>In over 20 clinical cases and 60 experimental anastomoses, no instance of leakage at the ends of the suture line, i.e., at the mesenteric border on one side, has occurred.



Fig. 5.

Fig. 6.

Fig. 7.

Fig. 5. Placement of the anterior running catgut suture. The clamps have been rolled together.

Fig. 6. Removal of clamps. Tension is applied to the two ends of each of the running sutures, the clamps are carefully loosened until the tips are spread 1 or 2 millimeters and the clamps are cautiously and simultaneously removed.

Fig. 7. Reinforcement of the suture line. The ends of the posterior running stitch have been tied to the corresponding ends of the anterior strand and tension has been maintained during placement of Halsted mattress sutures of 2½ pound silk. With the latter placed, but not tied, sulfanilamide is applied in small amounts between the serosal surfaces to be approximated by them.

denied operation. There have been 2 deaths, a patient mortality of 13.3 per cent and a case mortality of 12.5 per cent, levels no different from the mortality for intestinal obstruction as a whole at this clinic (2). The cases are summarized in Table I. More detailed summaries of 6 cases are included to illustrate special points.

Patient No. 1. U. H. 702210, male, aged 39 days, was admitted November 20, 1940, in a dehydrated state with a 60 hour history typical of intussusception. The abdomen was tympanitic and too distended to allow palpation of a mass, which could, however, be felt high on the right on rectal examination. He was transfused and given 100 cubic centimeters of 0.9 per cent sodium chloride solution before operation, and was slowly transfused during the operation. Through a right lower rectus incision, an ileocolic intussusception was identified, and the apex was milked back into the ileum, but the lesion could not be completely reduced despite considerable

manipulation; efforts were terminated by occurrence of a serosal tear. The upper margin of the intussusciens was observed at this point to be discolored, edematous, and firmly sealed to the bowel above it. The apex could be pushed about 2½ centimeters above the ileocecal junction. The involved area was resected from this point to a site 5 centimeters above the upper margin of the intussusciens, and an aseptic, end-to-end anastomosis of the Martzloff-Burget type was performed with catgut used for the internal layer. About 1 gram of sulfanilamide was implanted, partly about the anastomosis and partly in the wound during catgut closure.

After operation the patient was given 100 per cent oxygen, nasal gastric suction was used, and sodium sulfathiazole was given intravenously for 36 hours. Feces were passed at 48 hours, and the temperature reached normal at 72 hours. Early feeding was cautious, but the patient improved rapidly and was dismissed 22 days after operation. He was last seen 4 months later, and seemed a normal baby at that time.

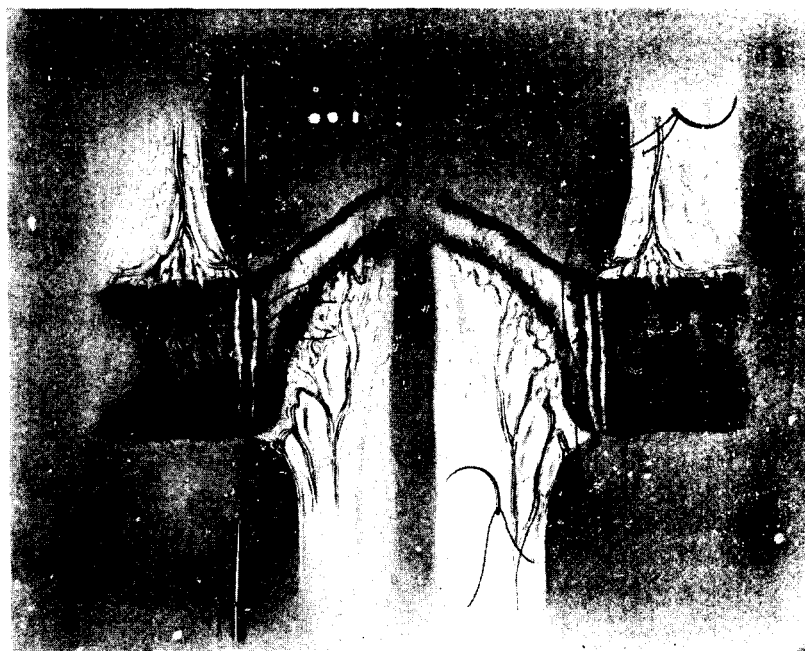


Fig. 8.

Fig. 9.

Fig. 8. Tying of the Halsted mattress sutures, with maintenance of tension on catgut strands. The posterior side is treated in similar fashion.

Fig. 9. Rear view of anastomosis, showing placement of stitch to close the mesenteric defect.

The specimen presented areas of necrosis, and there was hemorrhagic infiltration of the gut wall.

Patient No. 3. U. H. 614765, female, aged 71 years, was admitted March 24, 1941, 24 hours after an old umbilical hernia had become incarcerated. Pain had become severe and constant, and vomiting was profuse. Examination showed a hernia the size of a man's head; it was very tender to touch, and the entire abdomen was tender and silent. Temperature was 98 degrees.

At operation the patient went into profound shock as soon as the transverse skin incision had been made. Following transfusion of blood and plasma, the pulse became perceptible and gradually improved. The hernia contained some colon, the cecum, the appendix, and much of the ileum. When the hernial ring was cut, the color returned to most of these viscera, but 125 centimeters of upper ileum remained black and nonmotile. This segment was resected, and oblique, aseptic, end-to-end anastomosis with implantation of sulfanilamide was performed. The hernia was repaired with silk, with great difficulty because of tension.

After operation nasal suction was used for 5 days and patient did nicely except for senile confusion and a moderate wound infection. She was followed after dismissal, and the hernia recurred 18 months later.

The specimen showed hemorrhagic infarction of the bowel.

Patient No. 5. U. H. 708767, female, aged 53 years, was admitted May 7, 1941. The patient had had many previous operations, one for adhesions. She was admitted after 48 hours of nausea and severe, colicky, abdominal pains. On admission to the hospital there were borborygmi with typical cramps. Within 12 hours she developed abdominal tenderness and rebound tenderness, and the temperature rose to 102 degrees; she was, therefore, subjected to exploration.

At operation through a left lower rectus incision, a 15 centimeter piece of ileum was found herniated beneath an adhesive band running from the dome of the bladder to an old subumbilical scar. This bowel was black, and was, therefore, resected, and a primary, oblique, aseptic, end-to-end anastomosis was performed with implantation of a total of 1¼ grams of sulfanilamide. Because of the marked distention, a catheter enterostomy was performed proximal to the suture line.<sup>1</sup> Because there was a drop in blood pressure late in the procedure, the wound was closed rapidly, with a running suture of catgut.<sup>2</sup>

<sup>1</sup> This is the only case in the present series in which this precaution was taken.

<sup>2</sup> Catgut closure has been used on 3 intestinal obstruction cases because of the poor condition of the patients (Case 1, this case, and 1 case without resection). Two of the 3 have developed hernias. In 1 case in which heavy silk was used (Case 3), because of a large hernial defect, hernia developed in the wound. In most of the remainder, whether with gangrenous bowel or not, fine silk has been used in the closure, and no wound complications have developed except in 1 case there was peritonitis (Case 12) and in another superficial infection (Case 10).

Nasal suction was discontinued in 6 days, the patient was dismissed in 15, and the enterostomy tube was withdrawn in 19 days.

Examination of the specimen showed hemorrhagic infarction.

The patient was thrown from her seat in an automobile accident on her way home, and developed immediate pain in her wound, followed by hernia formation. A year later, because of pain, this hernia was repaired. The ileum for a total of 70 centimeters above and below the old anastomosis was densely bound to the sac by scar tissue and was, therefore, removed; reanastomosis was performed as before. The patient has apparently been cured.

The pathology report on this second specimen reads:

"At approximately the midportion of this intestine there is an oblique suture line with slight thickening of the peritoneal surface and induration. The circumference of the bowel along this suture line (measured on the mucosal surface) is 8.5 centimeters. The circumference measured directly transversely is 8 centimeters. The circumference 4 centimeters above the suture line is 8.4 centimeters and also 8.4 centimeters at a point 4 centimeters below the suture line. This is an old suture line with no signs of the sutures being found. There is no evidence of leakage. On cross section an annular rim or tissue follows the line of previous sutures."<sup>1</sup> (Fig. 17.)

Patient No. 7. U. H. 713329, female, aged 75 years, was admitted September 29, 1941. The patient presented a 5 week history of cramps relieved by defecation. Twenty hours before admission, she developed severe abdominal pain, nausea, coffee-ground vomiting, and loose stools. She had lost 30 pounds in a month. The patient had a history of heart failure, and she had auricular fibrillation on admission. She presented signs of peritoneal irritation, and a cauliflower-like mass could be felt on pelvic examination. Temperature was 98.6 degrees, white blood count 15,000. With the possibility of peritonitis from a ruptured appendix in mind, the patient was treated conservatively for 12 hours; then return of blood through the nasal suction tube led Dr. Lyle J. Hay (then resident in surgery at the University of Minnesota Hospitals) to diagnose mesenteric vascular thrombosis and explore the abdomen.

At operation the small intestine was found gangrenous except for 10 centimeters above and 60 centimeters below. Resection with primary aseptic anastomosis was performed by the Martzloff-Burget method.

After operation the patient was rapidly digitalized, and the pulse became regular. The nasal suction was discontinued 7 days after operation, but temporary stomal obstruction thereafter marred the convalescence for some days. Diarrhea was troublesome for a short time after recovery, but the patient was

<sup>1</sup> These data indicate that the crushing of tissue in the anastomosis clamp does not lead to subsequent contraction of the line of suture, for the length of the area of crush at the first operation was 5 centimeters on the serosal surface.

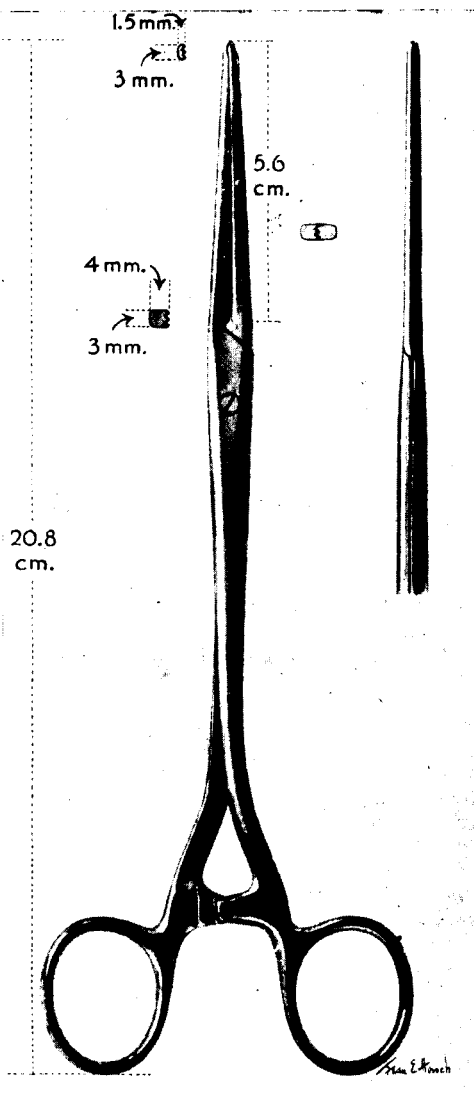


Fig. 10. The anastomosis clamps.

dismissed 26 days after surgery. She failed all her return appointments and stopped taking her digitals.

The specimen was 175 centimeters long after fixation, and of this, 80 centimeters was gangrenous due to mesenteric arterial thrombosis.

Patient No. 7 (second resection). This patient was readmitted October 12, 1942, after 19 hours of vomiting, cramps, and severe abdominal pain felt also in the back. With the limited length of small bowel remaining after her first resection, she had maintained excellent health, had had a voracious appetite, and had lost but 3 kilograms in a year. On

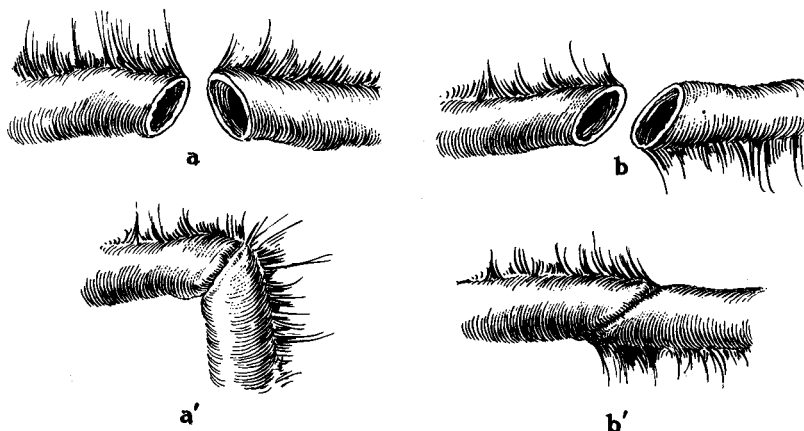


Fig. 11. a, Schematic drawing to illustrate the angulation resulting from end-to-end anastomosis of bowel cut at 45 degrees and opposed without rotation. b, The obviation of angulation accomplished by rotation of one segment with respect to the other is apparent. (Reprinted from *Surgery*, 1939, 5: 548.)

this 2d admission, the abdomen presented signs of marked peritoneal irritation, motion of the uterus was very painful, the gastric aspiration was bloody, and the electrocardiogram showed auricular fibrillation. Gangrene of the remaining small bowel was diagnosed, and the patient was rapidly (5 hours) digitalized, hydrated, and laparotomized.

At operation the remaining jejunum and ileum were found gangrenous and the abdomen contained fecal-appearing free fluid. The circulation to the cecum and duodenum seemed adequate. The ligament of Treitz and the lateral peritoneal attachment of the cecum and ascending colon were severed to allow approximation of the terminal duodenum and ascending colon, and an aseptic end-to-side anastomosis was performed, with inversion of the stump of the ileum. A total of 6 grams of sulfathiazole was implanted. Closure of the abdomen was made with steel.

On the 4th day after operation, the patient developed a right saphenous thrombophlebitis; this responded nicely to procaine lumbar sympathetic block. On the 7th day the patient developed pulmonary edema, probably from excessive fluid administration (she gained to 57.2 kilograms from the initial dehydrated level of 54.6 kilograms). Positive pressure of 8 millimeters of mercury was applied by using an anesthesia mask and a mixture of helium and oxygen; after 12 hours of such administration for 20 minutes every 4 hours, she appeared to have recovered, became mentally alert, and took cream of wheat by mouth. On the afternoon of the 8th day, she had an attack of cyanosis followed by stupor and apparent weakness of the left arm. Oxygen was administered. She did not again improve, and although the abdomen remained soft and bowel movements continued, she lost strength, had repeated attacks of cyanosis, and died 9 days after operation.

After removal of the nasal suction tube, 4 days after operation, it was observed that ingested food usually was passed in still recognizable form in less than a half hour.

The specimen removed at operation consisted of 130 centimeters of small intestine as measured in the fresh condition. Thrombi were present in both arteries and veins, and the bowel was gangrenous throughout all but 5 to 6 centimeters at each end.

Autopsy revealed a clean abdomen. The suture line anteriorly was covered by omentum. When this was removed, the suture line could be pulled apart with very little tension, and a small abscess was found between mattress sutures (a point at which there had been about 1 c.c. of spillage during the anastomosis). The mucosal surface of the line of anastomosis showed a more ragged and necrotic appearance than usual at this stage. On the wall of the colon opposite the duodenocolostomy a large, deep ulcer (5 by 7 cm.) was present. The remaining ileocolic vessels and the main trunk of the superior mesenteric vein were filled with a large fresh thrombus.<sup>1</sup> The mitral valves showed a subacute bacterial endocarditis with fresh vegetations, and fresh infarcts were found in the kidneys, spleen, and brain.

It would seem that this patient was lost not through any inherent defect in the anastomotic methods under discussion, but rather because the necessary resection exceeded in magnitude the limit which one can tolerate, and because of a complicating bacterial endocarditis.

Patient No. 10. U. H. 718626, female, aged 68 years, was admitted March 19, 1942. There was a 36 hour history of irreducibility of an old left lower

<sup>1</sup> This is the only case in the series in which there has been evidence of propagation of thrombus after resection of gangrenous bowel.



TABLE I.—SUMMARY OF CASES

Patient No.	Age	Type of obstruction	Duration	Length resected cm.	Type of anastomosis	P.O. duration of suction	Outcome	Length of hosp. stay days
1*	39 da.	Intussusception	60 hr.	8	Martzfloff-Burget†	36 hr.	Well	22
2	8 yr.	Volvulus—enteric cysts	36 hr.	45	Oblique aseptic	4 days	Well	12
3*	71 yr.	Ventral hernia	48 hr.	125	Oblique aseptic	5 days	Well	21
4	46 yr.	Ventral hernia (Richter)	72 hr.	30	Oblique aseptic	6 days	Well	11
5*	53 yr.	Internal hernia	48 hr.	50	Oblique aseptic	6 days	Well	15
6	24 hr.	Vascular occlusion	2 weeks	60	Martzfloff-Burget <sup>1</sup>	5 days	Well	13
7	75 yr.	Vascular occlusion	20 hr.	175	Martzfloff-Burget <sup>2</sup>	7 days	Well	26
Second admission 1 yr. later:								
	76 yr.	Vascular occlusion	24 hr.	Rest of jejunum and ileum	Aseptic end-to-side duodenocolostomy	4 days	Died	9
8	11 mo.	Intussusception	40 hr.	10	Martzfloff-Burget <sup>2</sup>	36 hr.	Well	24
9	53 yr.	Adhesions and vascular occlusion	60 hr.	34	Aseptic end-to-end ileocolostomy	6 days	Well	14
10*	68 yr.	Femoral hernia	41 hr.	50	Oblique aseptic	4 days	Well	21
11	47 yr.	Vascular occlusion	40 hr.	40	Oblique aseptic	5 days	Well	14
12*	55 yr.	Femoral hernia (Richter)	10 days	10	Oblique aseptic	6 days	Died	19
13	50 yr.	Femoral hernia	16 hr.	10	Oblique aseptic	3 days	Well	12
14	69 yr.	Vascular occlusion	5½ days	72	Aseptic end-to-end ileocolostomy	5 days	Well	9
15	57 yr.	Inguinal hernia	36 hr.	30	Aseptic end-to-end <sup>3</sup> ileocolostomy	5 days	Well	12

\* Additional data in case summaries in the text.

† The procedure here used differs from that of Martzfloff and Burget in that the internal, running stitch has always been catgut, not silk.

<sup>1</sup> Procedure by Dr. A. J. Kremen, fellow in surgery at the time, now in the armed forces.

<sup>2</sup> Procedure by Dr. Lyle Hay, fellow in surgery at the time, now in the armed forces.

<sup>3</sup> Procedure by Dr. Bernard G. Lannin, resident in surgery.

quadrant hernia, with abdominal cramps, lumbar pain, and vomiting. On examination the positive findings were auricular fibrillation, hypertension, a left lower quadrant hernia, 16 by 10 centimeters and bluish discoloration of the skin over the hernial protrusion. The abdomen was silent.

At operation, incision as for Bassini hernioplasty revealed the hernia to be femoral. An accessory vertical incision was made over the sac, forming a T incision. Ileum was found entering and leaving the neck of the sac, and exposure down to the sac permitted visualization through the wall of the sac of black bowel and blood black exudate. At the suggestion of Dr. R. L. Varco,<sup>1</sup> then resident on surgery, the bowel was cut between clamps as it entered and left the sac, and the sac itself was excised intact and without contamination of the wound with the contents. An oblique, aseptic, end-to-end anastomosis with implantation of about 100 milligrams of sulfathiazole was accomplished, and the necessarily severed inguinal ligament and the hernial defect were repaired with 5 pound test silk.

After operation the patient was rapidly digitalized, and the pulse became regular. Nasal suction was

<sup>1</sup> This is to be reported separately.

used 4 days, and a soft diet was allowed at 6 days after operation. A superficial wound infection delayed dismissal of the patient until 3 weeks after operation.

Inspection of the hernial sac showed the content to consist of 30 to 40 centimeters of gangrenous bowel and some omentum.

This method of dealing with hernias containing dead bowel and free fluid offers promise of saving a certain number of patients who have in the past been lost. It would have improved chances in Case 12 if she had come a few hours earlier.

Patient No. 12. U. H. 721428, female, aged 55 years, was admitted June 3, 1942. This patient presented a 10 day story of illness beginning with sudden severe abdominal pain, continued vomiting and cramps, and finally 6 days of conservative therapy with nasal suction and intravenous fluid administration at a local hospital. The patient was transferred to the University Hospitals on the day abdominal tenderness and fever appeared. Examination

showed a full abdomen, rather tender to deep pressure, but the patient arrived heavily sedated. The abdomen was silent except for rare gurgles; there were no cramps. No hernias were found on careful search. Temperature was 101.2 degrees, white blood count 11,000, blood urea nitrogen 59 milligrams per cent.

Attempts to pass a Miller-Abbott tube were not successful. In doubt for a definite diagnosis, 12 hours was allowed to pass in order to establish better hydration before exploration. With the patient still clouded mentally and the temperature over 105 degrees by rectum, operation was undertaken.

The serosal surfaces were angry red in appearance; the upper ileum was distended to 6 centimeters in diameter. Fecal material was found on the serosal surfaces in the right lower quadrant, emanating from a Richter's hernia into the femoral canal. Adjacent to the ring, the bowel had perforated, leaving a fibrin-covered rent. The sac was curetted and drained extraperitoneally after it had been packed with sulfathiazole and the peritoneal defect had been closed. The involved bowel was resected and an oblique aseptic end-to-end anastomosis was made with implantation of sulfathiazole. The abdomen was closed with running No. 1 20 day chromic catgut with further sulfathiazole implantation.

The patient failed to recover consciousness. Despite good urinary outputs (1 to 2 liters) the uremia progressively deepened. Twitching of one side of the face occurred, suggesting cerebral accident. Wound infection and dehiscence to the peritoneum occurred, and the patient died 19 days after operation. For the last week she was fed by drip feedings through an inlying nasal gastric tube.

Postmortem examination showed general peritonitis, most severe in the region of the right femoral canal. The anterior line of anastomosis was found to leak midway between the mesenteric and the anti-mesenteric borders. Examination of the specimen implied inadequate space between the 2 lines of suture. Permission to examine the brain could not be obtained.

At the time of the performance of this anastomosis effort was being directed to the inversion of as little tissue as possible, and to the placement of the two rows of sutures very close together, a policy which has now been dropped.

#### THE SURVIVAL OF DOGS FOLLOWING ANASTOMOSES BY VARIOUS METHODS AFTER ILEAC OBSTRUCTION

The literature does not contain many favorable references to the application of primary anastomosis of any kind to cases of small bowel obstruction. Owings and Smith published experimental results indicating that

primary, open, side-to-side anastomosis is feasible after resection of all bowel which is either distended, nonresponsive to stimuli which normally cause contraction in the dog, or which does not offer normal resistance to the passage of a suture needle. They had a considerable mortality, although it dropped to zero in the last group of dogs, in which they performed very extensive resections. They did not apply the method to clinical cases. Aside from this article, the author has not found any serious discussion in the literature of application of primary anastomosis as a procedure of choice in obstruction with non-viable or doubtfully viable bowel.

*Procedure.* In order to test the feasibility of primary anastomosis in the presence of obstruction in dogs, and also to evaluate one anastomotic method against another, a series of experiments was performed on 28 dogs. Adult male dogs of about 40 pounds were routinely used. About a half hour before anesthesia,  $\frac{1}{2}$  to  $\frac{1}{4}$  grain of morphine sulfate and  $\frac{1}{50}$  grain of atropine sulfate were given subcutaneously. Following ether induction, a soft rubber intratracheal tube was placed and rendered tight by securing the mouth about the tube. A very constant level of anesthesia was maintained by use of a standard laboratory ether bottle. A left rectus incision was made, and the ileum 25 centimeters above the ileocecal junction was divided between clamps, the ends being phenolized, alcoholized, and inverted with a Parker-Kerr No. 40 commercial cotton suture (11). Closure was secured with 3 interrupted Halsted mattress sutures of the same material. The latter sutures were used to tie the inverted ends together as a precaution against intussusception, and the abdomen was closed in layers.

The dogs were returned to a room in which the temperature was held between 80 and 85 degrees F., a precaution which cut the loss from pneumonia from 50 per cent almost to zero. Following obstruction, fluid was supplied intravenously in the form of 0.9 per cent sodium chloride, 750 cubic centimeters being given twice daily.

At an interval of days after obstruction, the animals were given 0 to  $\frac{1}{4}$  grain of morphine sulfate and  $\frac{1}{100}$  grain of atropine sul-

fate, and anesthetized as before with ether. Through a right rectus incision the area of obstruction was delivered, and anastomosis was performed in one of 3 ways: (1) open, side-to-side, with 2 rows of No. 00 catgut to short-circuit the fecal stream without resection; (2) oblique, aseptic, end-to-end anastomosis, as described earlier in this paper, but without sulfonamide implantation; or (3) oblique, aseptic, end-to-end anastomosis with implantation of a total of 60 or 70 milligrams of sulfanilamide in the interval between the suture lines. The dogs were regularly given isotonic sodium chloride solution intravenously the day of operation, water by mouth the 2d day, milk the 3d, and horse meat and mixed table scraps were given from the 4th day.

*Experimental results.* The dogs usually vomited 48 hours after obstruction, and the vomitus usually became fecal in character in 72 to 120 hours. Frequently the abdomen became distended.

Eight dogs died after obstruction and before anastomosis. Two of these were obstructed in the presence of diarrhea, and died of chemical imbalance which was not understood. Two died of perforation at the site of obstruction; the first had been obstructed by division and double pursestrings, a procedure which was therefore abandoned; the other bowel perforated through a suture hole which was evidently placed too deep. One died of pneumonia, 1 of an abscess resulting from subcutaneous instead of intravenous fluid administration, and 1 died of intussusception of the whole site of obstruction as far as the pelvic colon. Finally, 1 dog was used as a control, and survived 12 days, the abdomen being clean at autopsy.

The second operation was undertaken, as a rule, after 5 to 7 days of obstruction, but there were 2 instances in which this interval was 8 days, 3 of 4 days, one of 3 days, and one of 2; all these survived.

Careful notes of the condition of the distended bowel were made at the time of most of the anastomotic procedures. In the 4 to 8 day group of animals, the ratio of the diameter of the bowel above the obstruction to that below ranged from 2 to 5.2, with a mean

of 2.7 times. The actual diameter was at times as great as 6 centimeters. As Owings and Smith observed, the bowel above the obstruction usually had an edematous appearance. In 8 of the 9 instances in which definite mention was made of the color of the bowel, it was described as discolored or cyanotic. In 2 additional cases the bowel was gangrenous, 1 with a frank perforation sealed by the omentum<sup>1</sup>; in each of these instances the gangrenous areas were resected with a margin of less than 10 centimeters, and both recovered.

In all the 4 to 8 day group, the proximal bowel offered much less resistance to the passage of the needle than the distal bowel, and sutures could be tied only tight enough for apposition, lest they cut into the edematous proximal bowel wall. In the majority of instances, pinching of the bowel just proximal to the site of suture line failed to evoke contraction of the musculature.<sup>2</sup> If such a segment is tested for bursting strength, it is found to be greatly weakened below the normal level of 450 to 550 millimeters of mercury. In 9 instances in which this was checked, the mean bursting strength was 209 millimeters, the minimum was 72 millimeters and the maximum 320 millimeters.

Following reanastomosis in the successful cases, profuse diarrhea was usually observed within an hour or two. Water was usually taken the same day, and food as soon as it was offered.

From the point of view of survival, those animals which returned to a full diet and in which subsequent examination of the specimen revealed a firm anastomosis with adequate stoma were considered satisfactory; a few of these were lost in an epidemic of distemper, and some were lost in a heat wave. Those which failed to achieve normal gut function were considered failures, with the exception of 1 dog with an open and 1 dog with a closed anastomosis, which died 1 day after surgery in the heat wave which killed also some unused stock animals; these have been included as satisfactory anastomoses because

<sup>1</sup> This dog had been obstructed 8 days. In this animal and in one 5 day experiment the author had the privilege of testing the aseptic decompressing device devised and reported by Wangenstein (14) prior to the application of it to clinical cases. It was also used in Patient No. 9, Table I.

<sup>2</sup> These changes also were observed in almost all the clinical cases.

they looked excellent at postmortem examination and did not seem to have contributed to death. One dog was kept open over 2 hours on a cool day for photographs and died of atelectasis within a day; this was omitted.

The results of these experiments are summarized in Table II.

TABLE II.—ANASTOMOSIS IN THE DOG FOLLOWING ILEAC OBSTRUCTION

Type of anastomosis	Number of dogs	Unsatisfactory		Satisfactory	
		Leakage	Obstruction	Number	Per cent
Open side-to-side	4	1	1 <sup>1</sup>	2	50
Oblique, aseptic, end-to-end					
Without sulfanilamide	6	1 <sup>2</sup>	0	5	83
With sulfanilamide	10	0	0	10	100

<sup>1</sup> This obstruction was partial and contributed to death 11 days after operation.

<sup>2</sup> This resulted from clumsiness at operation, which led to a longitudinal tear near the suture line, inadequacy of blood supply resulting.

#### THE HEALING OF ANASTOMOSES PERFORMED ON BOWEL WHICH HAS BEEN SUBJECTED TO DISTENTION AS A RESULT OF OBSTRUCTION

Halsted devised an open end-to-end anastomosis performed with presection sutures. He pointed out several dangers which have been applied to anastomosis in general: (1) overinversion of tissue, causing either obstruction to the lumen or necrosis of the inverted tissue, or even necrosis at the suture line from tension; (2) too shallow placement of sutures, with inadequate grip and consequent tearing of the tissues, leading to loosening of the closure and peritonitis; and (3) too deep placement of the sutures, forming a tract through which peritonitis was observed to develop.

Halsted's specimens were studied microscopically by Mall, who confirmed the dangers of including mucosa in silk sutures, and observed a cyst-like adenomatous growth of mucosa through all but the serosal layers when this was done. In sections made 1 to 2 days after anastomosis, pus cells were frequently found in considerable numbers between the apposed surfaces. The mucosa did not become fully regenerated until about 3 weeks. He concluded that the inverted ridge or flange of tissue begins to unfold at about 4 weeks

and eventually unfolds to leave only an area of slight thickening.

Further studies by Holman and Sabin on anastomoses made by Halsted's technique corroborate the earlier findings in most regards, but in these later observations the mucosa healed completely in 9 days. Some of the published plates show no disappearance of the inverted flange after 10 weeks.

Martzloff, Moore, and Gardner (9) studied the healing of ileum after anastomoses over clamps by the Martzloff-Burget technique. They used silk for both layers, and their results, in the main, confirm those of Mall and Sabin. Their intumed flanges flattened out much more quickly, however, i.e., in 14 days, and the mucosa became entirely healed before 6 days had passed.<sup>1</sup>

Gerbode employed the Martzloff-Burget technique for gastroenterostomies in dogs, using 2 layers of interrupted silk in some instances and an inner layer of running catgut and external Lembert stitches of silk in others. He observed that the tissue which had been crushed in the clamps usually dropped off in 48 hours so that a granulating bed was left, which in turn was regularly overgrown by mucous membrane at 14 to 17 days. The line of apposition showed pus cells only around the sutures, and this area had regularly healed at 11 days by proliferative fibrosis. The size of the flange began to decrease at 14 days and remained at 28 days only as an area of slight thickening.

One may conclude from these reports that healing after the closed method of anastomosis is at least as rapid as it is after the open method.

Varco, Hay, and Stevens, of this clinic, broadened the field of intestinal surgery immensely when they discovered the improvement in healing of intestinal wounds which results from the local implantation of sulfanilamide. It is their impression that application of the drug inhibits fibrinolysis by the

<sup>1</sup> Of interest is their finding that 8.5 per cent of their anastomoses made in this fashion leaked fatally; when they used catgut for the internal stitch, the leakage rate was 23.5 per cent; and when they omitted the internal running suture altogether, 17 per cent leaked. In the oblique, aseptic, end-to-end anastomosis described in this paper there has been no instance of leakage when performed on normal bowel in over 40 instances. This security is due at least in part to the presence of peritoneum on at least one of the inverted surfaces at all points around the line of apposition. The majority of these anastomoses were performed without sulfanilamide implantation.



Fig. 12.



Fig. 13.



Fig. 14.



Fig. 15.

Figs. 12 to 15. Photomicrographs showing appearance of line of apposition of anastomosis made in the relief of 5 to 7 days' obstruction in the dog.  $\times 6$ . Sulfanilamide implanted.

Fig. 12. Appearance at 1 day. The area crushed by the clamps has not yet sloughed. There is firm serosal sealing, and both the cotton and the catgut sutures are visible. Under high power magnification, very few polymorphonuclear leucocytes are visible around either serosa or in the line of apposition, except in those areas where the tissue had been crushed.

bacteria from the intestinal lumen, and thus promotes primary union.

*Procedure in microscopic and gross examination of specimens.* Specimens were removed from almost all animals for sections of the suture line at varying intervals after anastomosis. They were removed, in the majority of instances, while the animals were still alive (the bowel being reanastomosed for control sections) or immediately after sacrificing by an overwhelming dose of sodium pentobarbital or ether given intravenously. Removed

Fig. 13. Appearance at 6 days. Healing is secure, and there is little evidence of inflammation. A granulating bed has formed at the luminal end of the line of apposition, and the mucosa is spreading over this area.

Fig. 14. Appearance at 18 days. The granulating bed is almost covered with a thin layer of epithelium. The catgut is still present. The defect at the base of the ridge of inversion contains a few wisps of cotton suture material.

Fig. 15. Appearance at 165 days. The line of suture is recognized only by the presence of a cotton stitch. The inversion ridge has all but disappeared in this specimen.

specimens were fixed in 4 per cent formaldehyde solution, and paraffin sections were cut at right angles to the suture line midway between mesenteric and antimesenteric borders. All sections were 6 micra thick and were stained with hematoxylin and eosin.

*Microscopic findings after obstruction.* Gross changes in the bowel resulting from obstruction have already been described. Microscopic examination of this distended bowel regularly reveals the following changes: edema of all layers, congestion, hemorrhage into the



Fig. 16. a, left, An anastomosis line in a dog 235 days after performance in the relief of obstruction without sulfanilamide. The ridge of inversion is permanent, the usual result



in the canine suture lines. b, A similar specimen 51 days after anastomosis. The scar in the absence of sulfanilamide is usually heavier than with the drug.

tissues in some spots, and polymorphonuclear leucocytic infiltration also of many areas. Despite these changes, 1 of the 8 day obstruction specimens was found to have the mucosa completely healed over the tissue inverted at the time of obstruction.

*Healing after oblique, aseptic, end-to-end anastomosis with sulfanilamide implantation.* One day after anastomosis the area crushed by the clamps has not yet sloughed (Fig. 12). There is firm sealing of the apposed serosal surfaces, and both the catgut and a cotton suture can be seen. Under higher power the line of inversion between the catgut and the necrotic crush shows some polymorphonuclear leucocytic infiltration, and a few also may be seen about both sutures. There is no evidence of mucosal regeneration.

Six days after anastomosis healing of the apposed serosal surfaces appears very secure (Fig. 13), and there is no low power evidence of inflammation. A granulating bed has formed at the luminal margin of the line of apposition, as Gerbode described, and a few leucocytes can be found here under higher power magnification. The mucosa is rapidly covering this area. The catgut and the cotton suture can be seen, neither surrounded by leucocytes.

Eighteen days after anastomosis a single layer of epithelial cells has almost covered the granulating bed at the luminal end of the line of apposition (Fig. 14). A few leucocytes are present in the mucosal edges, but not else-

where. The catgut stitch is still present. The defect at the base of the ridge of inversion results from penetration of the mucosa by a cotton stitch.

At 48 days healing appears complete, the catgut has disappeared, and the region of the anastomosis has become difficult to find. The situation remains essentially unchanged at 165 days (Fig. 15), when the point of anastomosis can be identified only by the finding of a cotton suture beneath the serosa. In this specimen, the inverted tissue is no longer apparent, and unfolding appears to have occurred, as described by Mall.

Unfolding of the inverted flange happened occasionally in the dog experiments and usually had occurred in the late human specimens obtained, but the more common end-result in the laboratory is illustrated in Figure 16a, a 235 day old anastomosis. There is complete healing of all the layers, but a 4 millimeter ridge remains. It was regularly found that the diameter of the gut above and below the point of anastomosis became identical within 2 weeks; in 1 instance this had occurred in 6 days.

*Healing after oblique, aseptic, end-to-end anastomosis without sulfanilamide implantation.* In the absence of sulfanilamide, healing progressed at the same rate as with it, but throughout the process there was much greater evidence of inflammatory reaction; this reaction has been interpreted as the result of greater bacterial growth. At one day,



Fig. 17a.

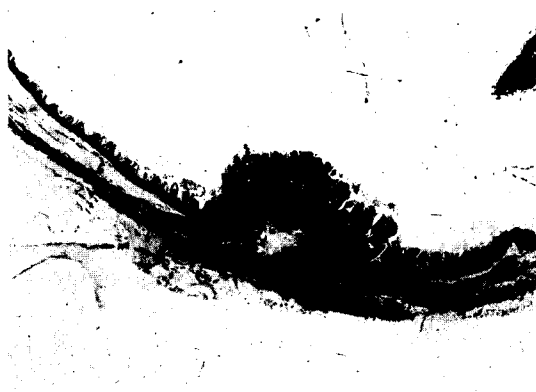


Fig. 17b.

Fig. 17. An anastomosis from a clinical case, made in the presence of obstruction 1 year before, with implantation of sulfanilamide. a, Gross appearance. The arrow indicates the point of anastomosis. b, Section through the line of apposition.  $\times 6$ . The ridge has not unfolded. A piece of the silk suture is present in the defect in the ridge—it extends over to the mucosal surface. c, Under higher power, polymorphonuclear leucocytes are seen still to be present in contact with silk suture.  $\times 215$ .

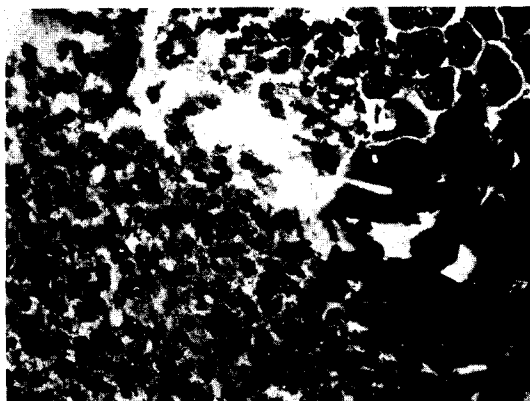


Fig. 17c.

there is heavy leucocytic infiltration about both the sutures and also in the line of apposition. It is still present at 6 days, but no frank liquefaction is recognized. The ultimate healing is as satisfactory as with sulfanilamide implantation, but there appears to be a heavier scar left (Fig. 16b).

*Healing after open anastomosis.* After open anastomosis, only 3 specimens are available. In these few, the most striking finding is a heavy infiltration of leucocytes around each suture and also in the line of apposition. The inverted cuff of tissue is greater than in the closed method, and apposition is far looser and results in a heavier scar than is the case in the closed procedure. It was apparently loose apposition which resulted in leakage in 1 of the dogs.

*Healing after oblique, aseptic, end-to-end anastomosis in the absence of obstruction.* The

mucosal repair reported above is far slower than that reported by Martzloff and his associates. With the thought in mind that obstruction might be responsible, studies were made on 11 anastomoses made in the absence of obstruction, some with and some without sulfanilamide implantation.

Healing progressed in these anastomotic sites in a fashion apparently strictly parallel to that seen after obstruction. At 7 days, when Martzloff found healed mucosa, the mucous membrane covers only  $\frac{1}{3}$  of the granulating surface. In search of some other factor, postoperative and preoperative feeding were considered. When the dogs were allowed only water and milk by mouth, it was found that at 5 days the epithelium had proliferated to the edge of the crush, which had not yet sloughed. At 11 days, healing of the mucosa is complete, and at 15 days, it was found

that glands have formed across the line of anastomosis.

*Healing in clinical cases after aseptic anastomosis.* A few clinical specimens have become available at varying intervals after anastomosis. In the duodenocolic anastomosis of Case 7, the specimen became available at autopsy, 9 days after operation. There was still a wide granulating area at the line of apposition internally, and a small abscess was found between mattress sutures anteriorly, as already mentioned. In Case 12, the patient had had peritonitis for nearly 3 weeks at the time of death, and there was very little healing evident; the wound edges pulled apart with minimal tension.

Two anastomoses, performed in the presence of obstruction but without strangulation, were obtained from the same patient, due to successive operations, the patient ultimately dying of peritonitis from contamination incident to a catheter enterostomy. The first was 9 days old; it shows the area of crush not yet sloughed. There are no leucocytes to be seen. The other was 24 days old at the time of death. Healing is excellent, and no leucocytes are visible; the mucosa almost covers the granulating area.

The specimen obtained from Patient No. 5, 1 year after anastomosis, shows intact healing. Grossly the suture line is difficult to find (Fig. 17). Section shows a silk stitch with polymorphonuclears about it, which is presumably being extruded into the lumen, an indication of too deep a bite. In spite of this, the amount of contraction of the suture line in a full year is too little to be demonstrable by measurement, as already mentioned.

Another year old specimen was obtained from Patient No. 7 at her second operation. The anastomosis had been performed by the Martzloff-Burget technique. The site of anastomosis was recognizable grossly by the presence of sutures beneath the serosa, and microscopically only by the abrupt change of mucosal pattern from high jejunal to lower ileac.

*Healing of experimental anastomoses made at the time of obstruction.* In 3 dogs, an oblique, aseptic, end-to-end anastomosis was performed 15 centimeters above the point of

obstruction, which was made at the same sitting.

In the first 2, sulfanilamide was not implanted, and the 2 rows of sutures were placed as closely as possible; death occurred from perforation, one in 3 days and the other at 5 days. The 3 day specimen was autolyzed. In the other, perforation had occurred beside a perforating cotton suture on the anterior suture line midway between the angles. Microscopic examination shows a perforation through the ileac wall where a wisp of remaining cotton is visible; there is also a great sheet of polymorphonuclear leucocytes between the apposed surfaces extending to the mucosa near the first perforation; a larger piece of suture is visible in this exudate.

In the third dog, sulfanilamide was implanted, at least 2 millimeters was allowed between the two rows of sutures, and the animal was milk-fed. The anastomosis healed despite distention and fecal vomiting. The dog died 19 days after operation, living much longer than control dogs subjected to obstruction alone.

#### OBSERVATIONS

The clinical results and the survival rates in the animal experiments leave little doubt concerning the relative safety of the anastomotic procedure described or the advisability of primary anastomosis in preference to other procedures. The technique, if adequate in the presence of obstruction and marked degrees of distention, is patently very safe for use in elective operations. In Case 7 there may have been some postoperative extension of thrombosis, but in no other instance was this observed. It seems justifiable to conclude that this fear, entertained by many, is not well founded.

Some discussion of the reasons for certain of the steps is in order. Early anastomoses were performed by the Martzloff-Burget technique. In many dogs the bowel is sufficiently small so that the anastomosis cannot readily be made secure without inversion of enough tissue to cause necrosis or obstruction. It was for this reason that rotation of the ends with greater obliquity of placement of the clamps was first adopted.



The device described of placing the clamp on the bowel of small diameter is fully as effective when both segments are of narrow lumen, and has been in regular use for end-to-end primary ileotransverse colostomies, the standard procedure in resections of the right colon for cancer at the University Hospitals.

In the Martzloff-Eurget anastomosis the internal running stitch is silk. In practice, this was found to offer too much friction, thus interfering with easy and clean inversion during removal of the clamps. Fine catgut serves admirably for this purpose, and application with an atraumatic needle minimizes tissue trauma during insertion.

Martzloff, Moore, and Gardner tried what they call the Scarff technique, namely placement of Halsted mattress sutures adjacent to the clamps without an internal running suture, but they found it impracticable because the stitches cannot be placed at right angles to the clamp and close to it with accuracy and therefore without frequently perforating the mucosa. For the reason that this procedure appeared, except for this difficulty, an ideal procedure, it seemed wisest to use the finest size of catgut that would suffice for the mechanics of the operation. The aim, therefore, is to apply the fine catgut only to hold the intestine during the placement of the important Halsted mattress stitches, and for the few minutes to an hour which are needed for serosal sealing to take place between the 2 rows of sutures.

Inasmuch as the removal of catgut is an exudative and liquefying as well as an absorptive process, it is likely to become infected in the course of healing, especially in this position. This is a further reason for the insertion of a minimum of foreign material by use of a very fine strand. It also is responsible for the impression that an expanse of serosa perhaps 2 millimeters wide should be left between the 2 layers of sutures, for healing would be less kindly if infection of the silk sutures were to occur. With observance of this principle, an anastomosis, made at the time of obstruction a few centimeters below it, healed despite distention, vomiting, and finally death from obstruction. The question needs more study.

The evidence presented in this paper indi-

cates that unfolding of the inverted flange cannot be counted on to enlarge the stoma, at least not within months. One must therefore invert enough tissue so as to assure a band of serosal approximation between suture lines, but not enough to interfere to any extent with the lumen. The obliquity of the suture line in the present technique minimizes the danger of obstruction from this source.

The data presented in this paper also are in line with the conclusions of Halsted and Mall that too deep placement of sutures is dangerous. Of the 4 perforations observed following the use of this anastomosis in the presence of obstruction (3 dogs and 1 patient), 1 at least occurred around a cotton suture that had pierced the mucosa. The placement of stitches which catch the bulk of the muscle but no submucosa would seem a less hazardous error only if they are tied loosely enough not to tear the tissues at the time.

With regard to the rate of healing in the presence of obstruction, the data presented indicate that the deeper layers heal fully as fast and securely as by other methods or in the absence of obstruction. With regard to the mucosa there is some question. The experimental animals were fed following obstruction in order to simulate the situation found in clinical cases, and they therefore had food and other matter in the intestine at the time of anastomosis. In any case, the mucosa healed in anastomoses after obstruction as rapidly as in unobstructed bowel in which the dogs were fed. The faster rate of mucosal healing, which has been reported by Sabin and Martzloff, could be approximated by starvation of the animals.

#### CONCLUSIONS

1. An oblique, aseptic, end-to-end anastomosis designed for use on intestine in the presence of obstruction is described.
2. A series of 16 resections for strangulating obstructions in clinical cases resulted in 2 deaths and 14 recoveries.
3. Laboratory study of this anastomosis indicates that it is highly reliable, either in the presence or absence of obstruction.
4. Healing in bowel that has been obstructed 5 to 7 days and then anastomosed by this

technique is apparently as rapid and secure as in the absence of obstruction.

5 Late contraction along the suture line apparently does not occur.

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